CFD Applications using Wind-US

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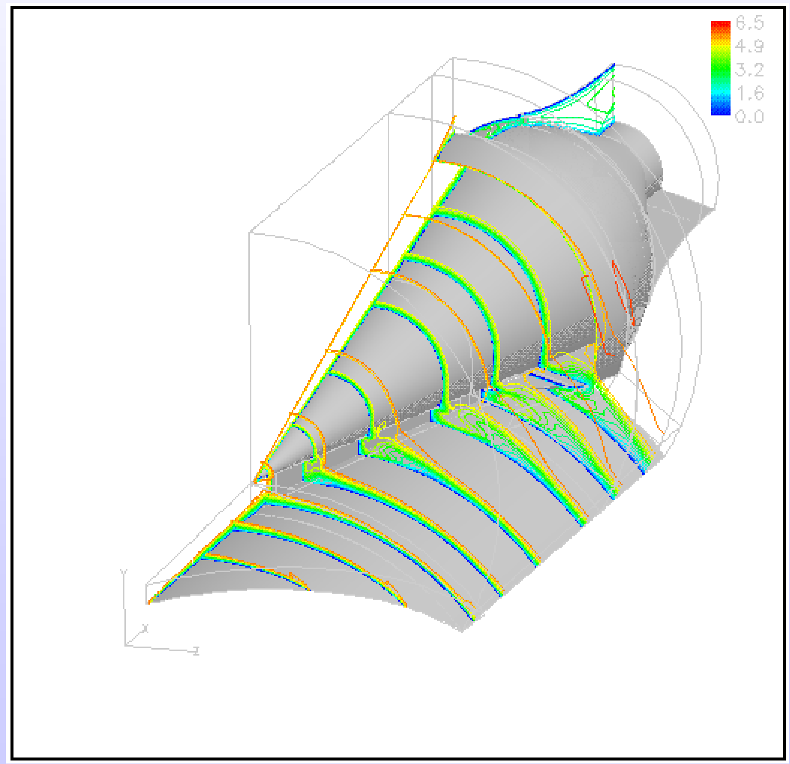
GTX Inlet

- Rocket-Based Combined Cycle (RBCC) Concept for single-stage to orbit (SSTO)
- Steady-state analyses
- Inlet Flow (Mach 6)
  - Support tunnel tests
  - Examine design options
  - Examine unstart sensitivities
  - Examine bleed options

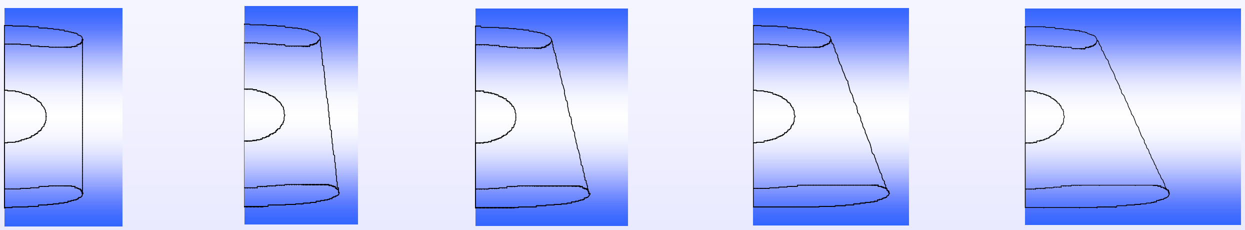


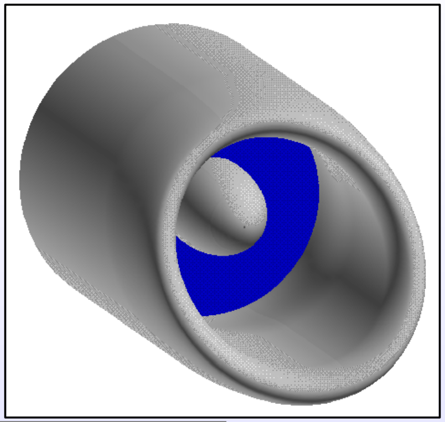
Researcher: John Slater (Inlet Branch)

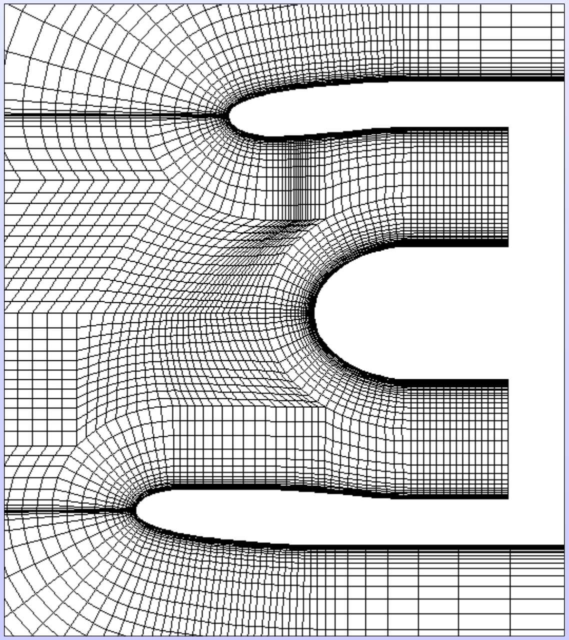
3D Subsonic Inlets

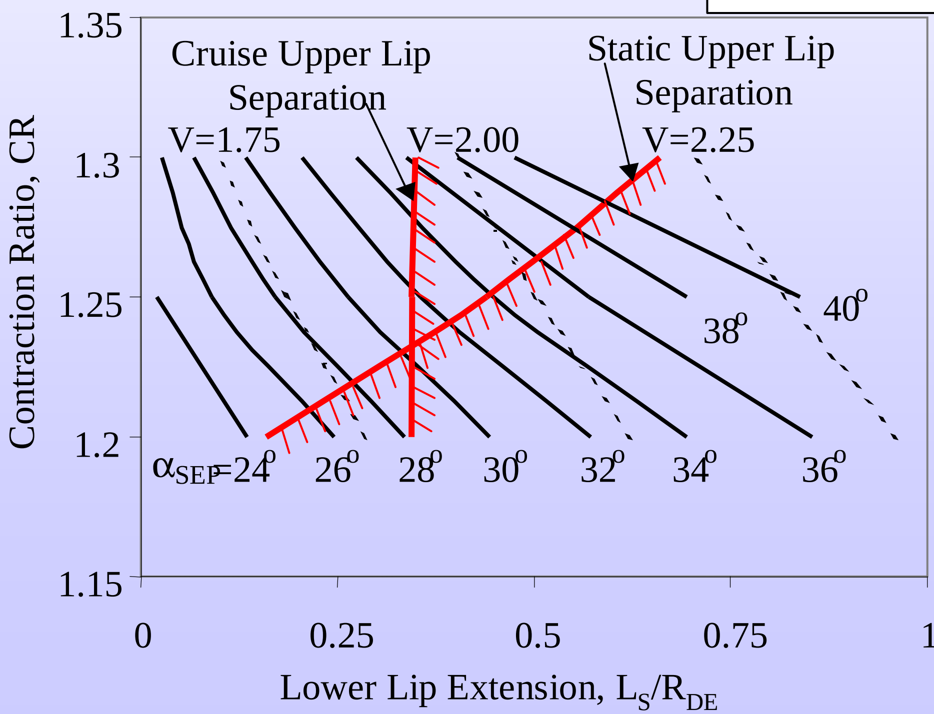
Design study on geometric parameters for 3D subsonic inlets

Researcher: John Abbott (Inlet Branch)









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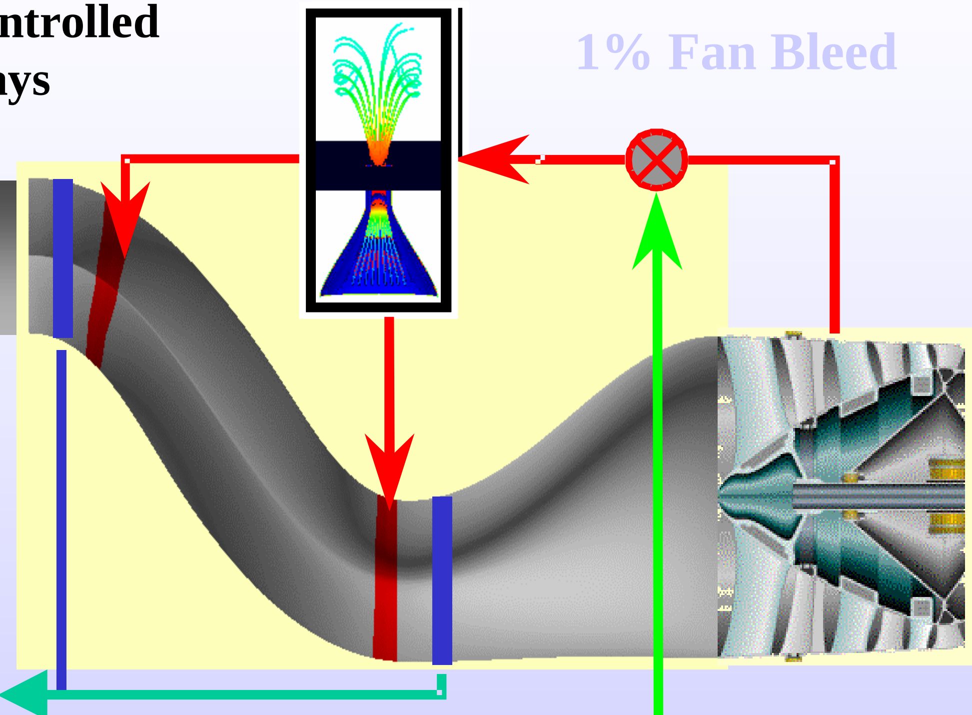
Active Inlet flow Control for Ultra-Intelligent Inlet/Engine Systems

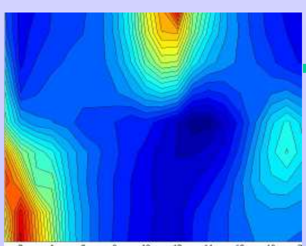
Independently Controlled Effector Arrays

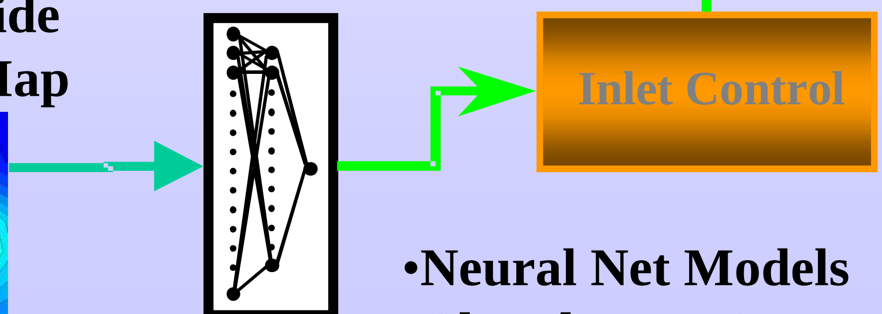
- **Inlet**
- **Variables:**
  - **Geometry**
  - **Inlet Air Flow**
  - **Mach Number**
  - **Angle of Attack**
  - **Sideslip**



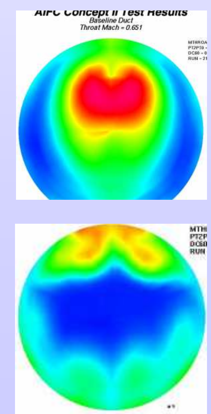
Output:
Tailored Inlet Flow Field for Optimized Engine Performance & Operability

Distributed Sensors Provide Flow State Map





- **Neural Net Models**
- **Closed Loop Control**



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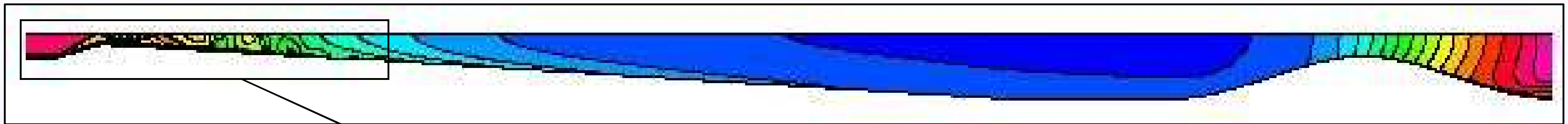
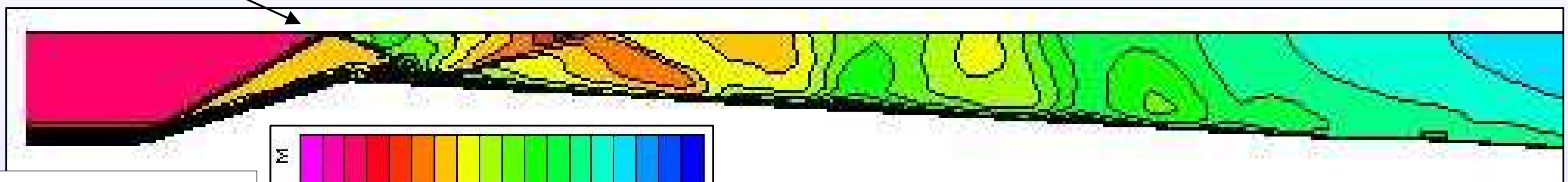
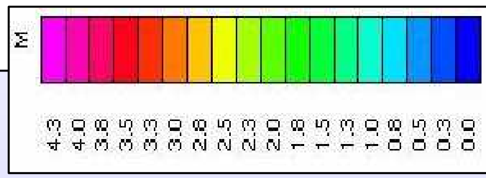
10x10 SWT Second Throat

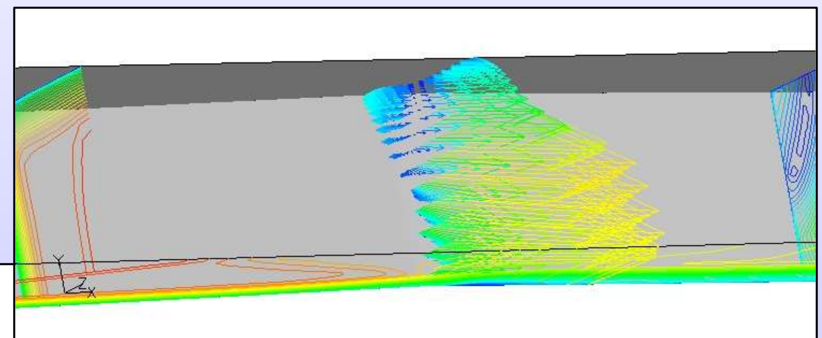




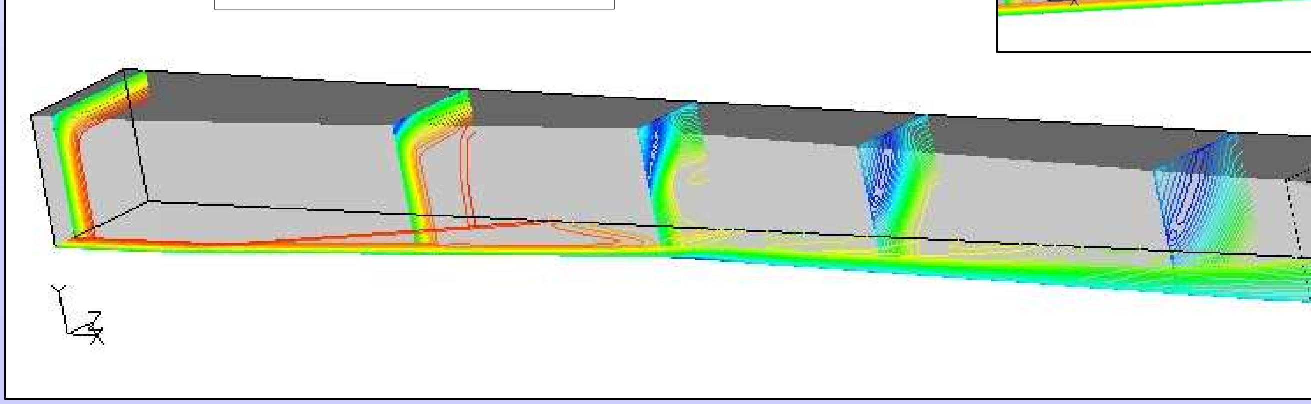


Existing Throat

Modifications to increase test section to Mach 4



Modified Throat



Researcher: John Slater
(Inlet Branch)

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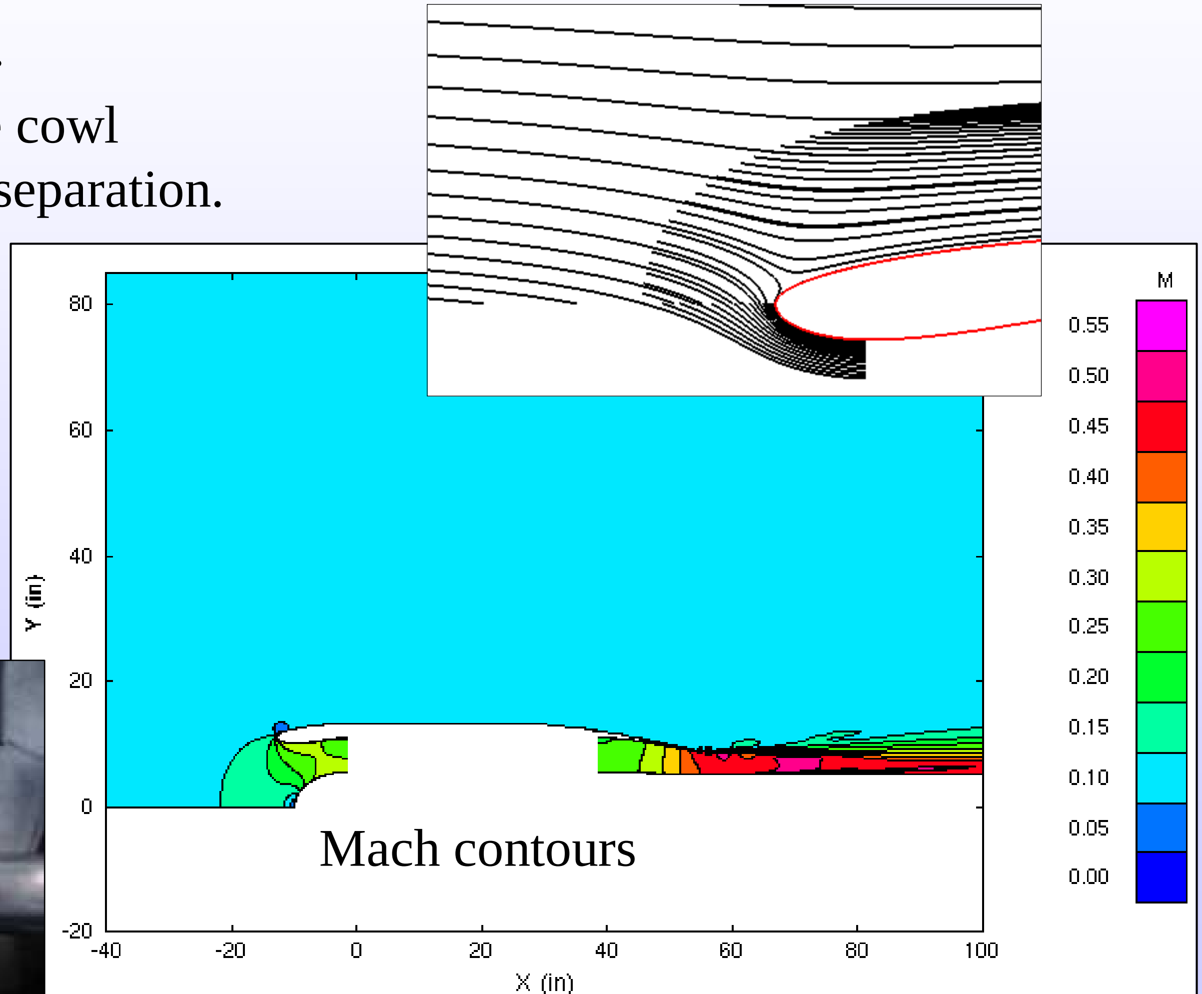
Tandem Fan Nacelle

- Matched design mass flow.
- Streamlines stagnate above cowl highlight; however, no separation.
- Uniform total pressure profile at fan face.
- Fan Mach = 0.2636
- Recovery: 0.9989



Researcher: John Slater (Inlet Branch)

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Rocket Engine Exhaust

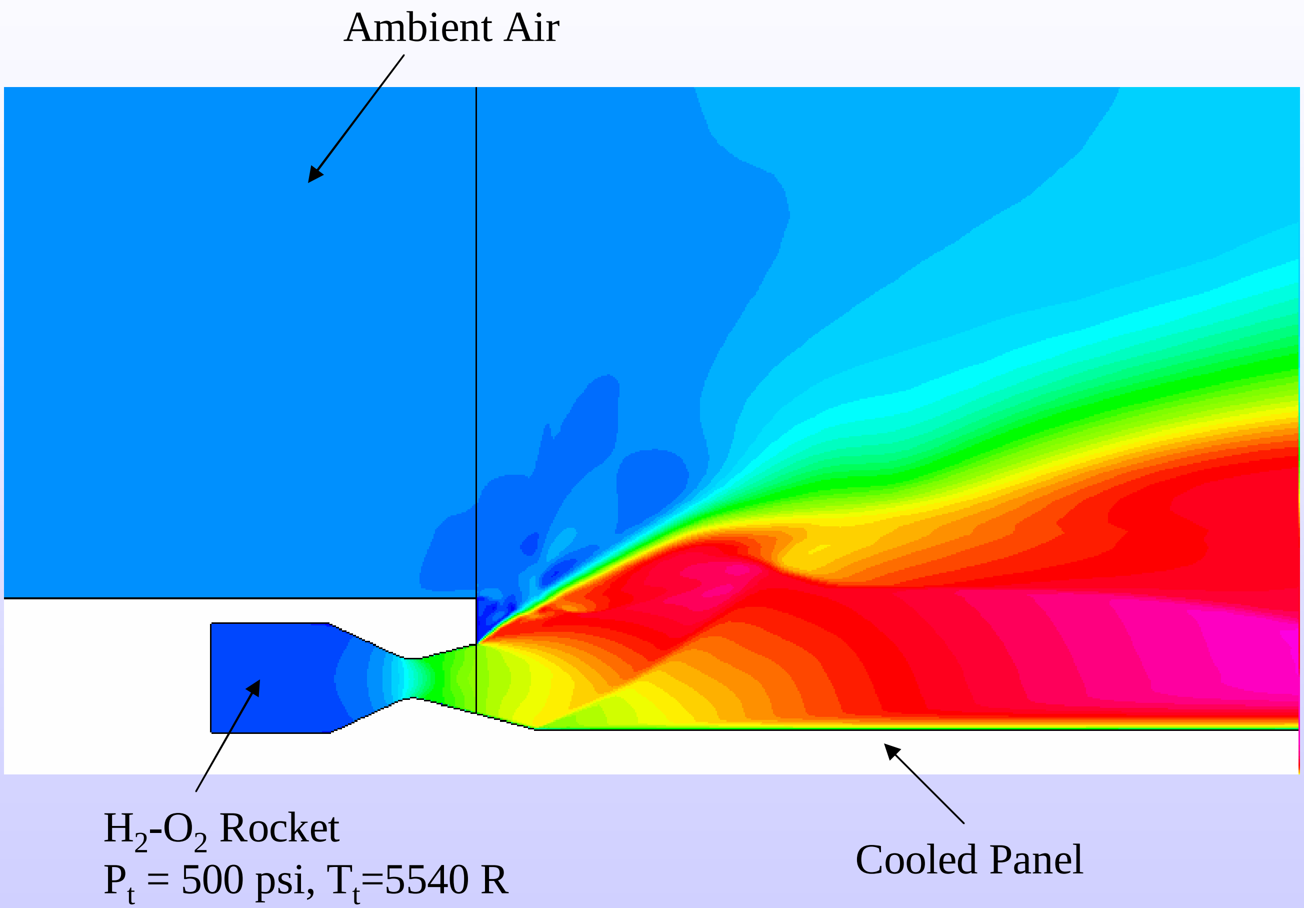
Frozen chemistry, seven species.

SST turbulence model.

Mach contours shown.

Used to compute heat transfer from plume to cooled panel.

Good agreement with data.



Researcher: Nick Georgiadis (Nozzle Branch)

Supersonic Cruise Nozzle

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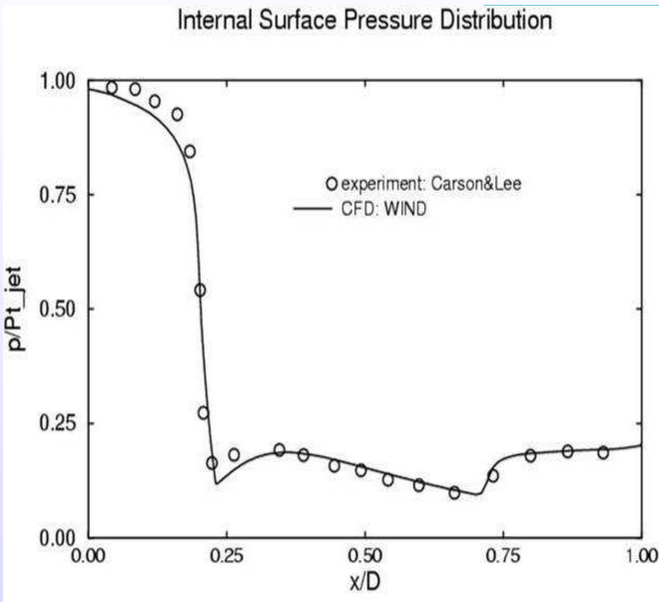
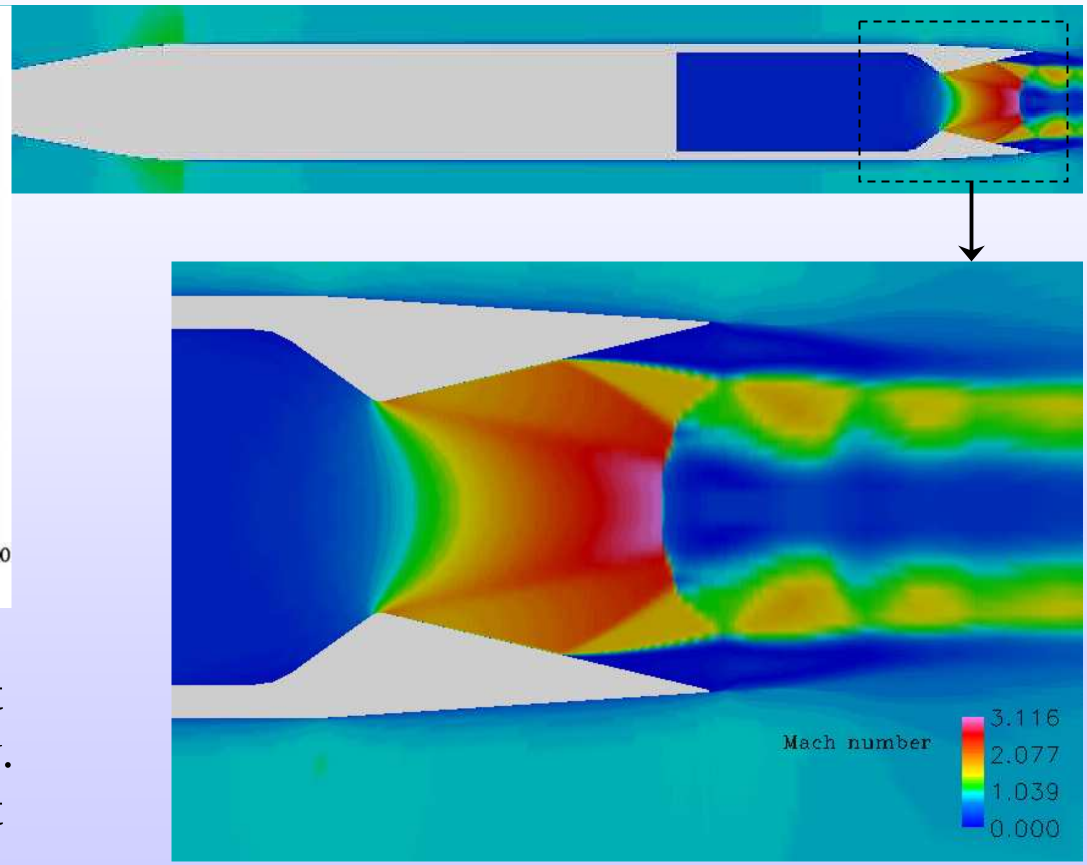




Validation case for NASA's Next Generation Launch Technology.

Reference NASA LaRC nozzle at off-design conditions.

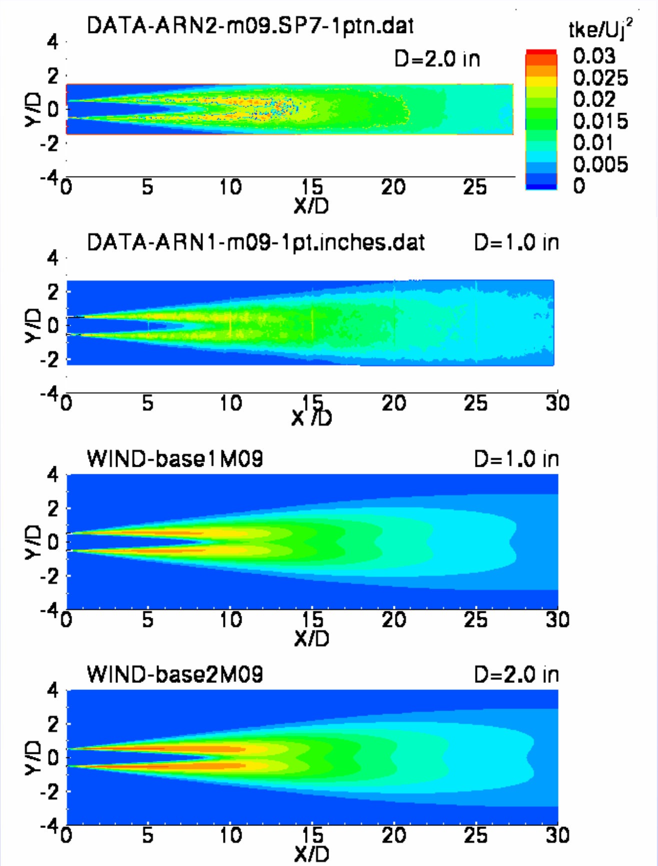
SST turbulence model.

Very good separated flow prediction.

Researcher: Teryn DalBello (Nozzle Branch)

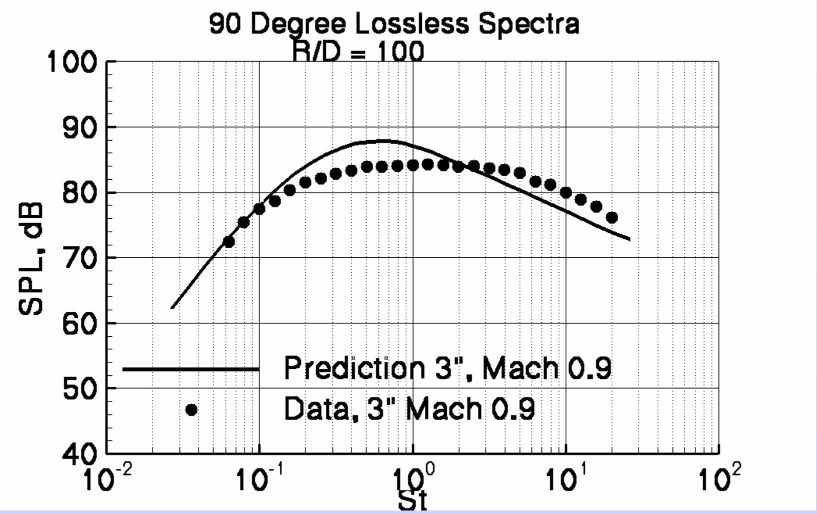
Jet Noise Prediction

- Jet noise predictions generated using WIND, and MGBK aeroacoustic code.
- Mean flow and k–ε results from WIND are input to MGBK.
- Accurate prediction of location and magnitude of turbulence kinetic energy is important if the mean flow results are used to estimate jet noise.



PIV Data / WIND Predictions

Normalized Turbulence Kinetic Energy Distributions, Mach 0.9



Acoustic Data / MGBK Predictions

Researcher: Danielle Koch (Acoustics Branch)

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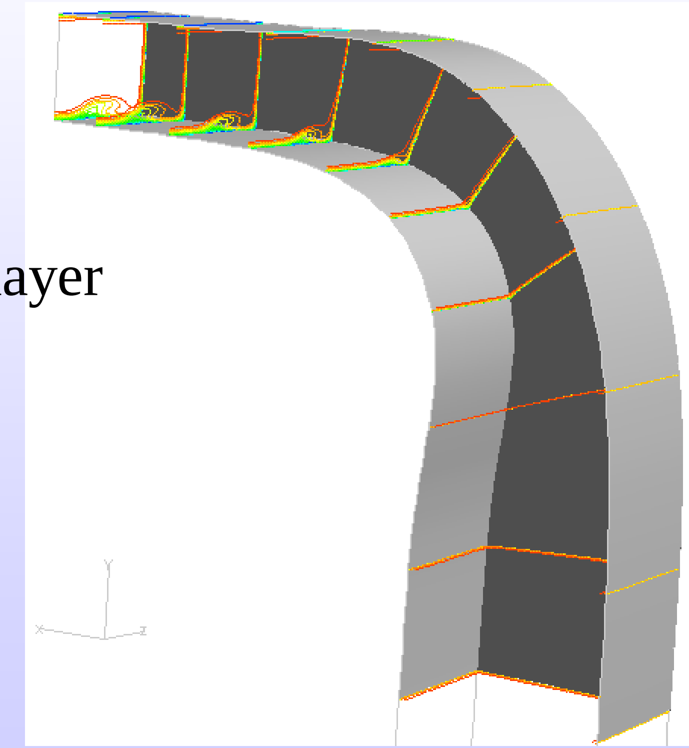
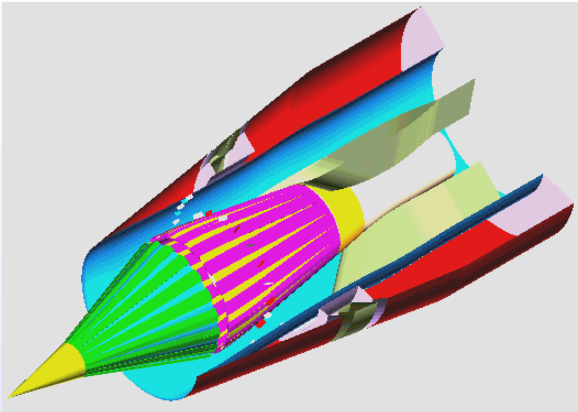
Stanitz Elbow

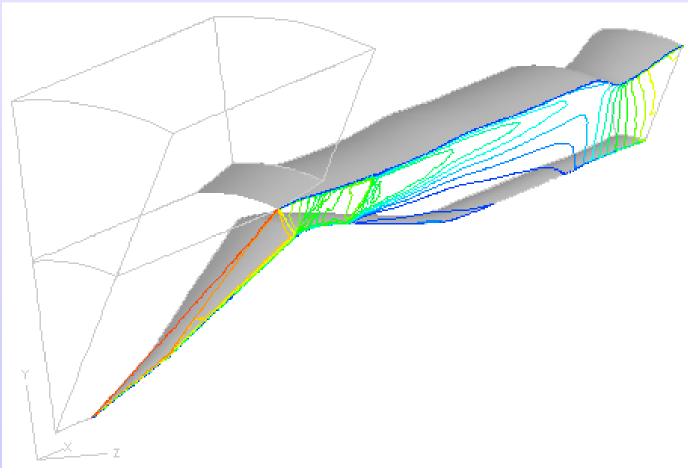
- 90º rectangular elbow (Stanitz et al., NACA, 1953)
- Incompressible flow (Mach 0.26)
- Secondary flow without separation
- Simple geometry and accurate grid
- Inflow BC matches inflow boundary layer
- Outflow BC matches mass flow
- Data (Stanitz et al., 1953)
  - Inflow boundary layer profile
  - Surface static pressures
  - Rake total pressure contours



NASA VDC Inlet

- $M_\infty = 2.35 \Rightarrow$ supersonic
- Mixed-compression inlet
- Axisymmetric CFD model
- No leaves, VGs, or struts
- Bleed slot (2.545% flow)
- Nozzle at exit for outflow
  - Match back-pressure of data
- Data (Saunders et al., 1993)
  - Centerbody static pressures
  - Cowl static pressures
  - Pressure recovery





Parametric Inlet

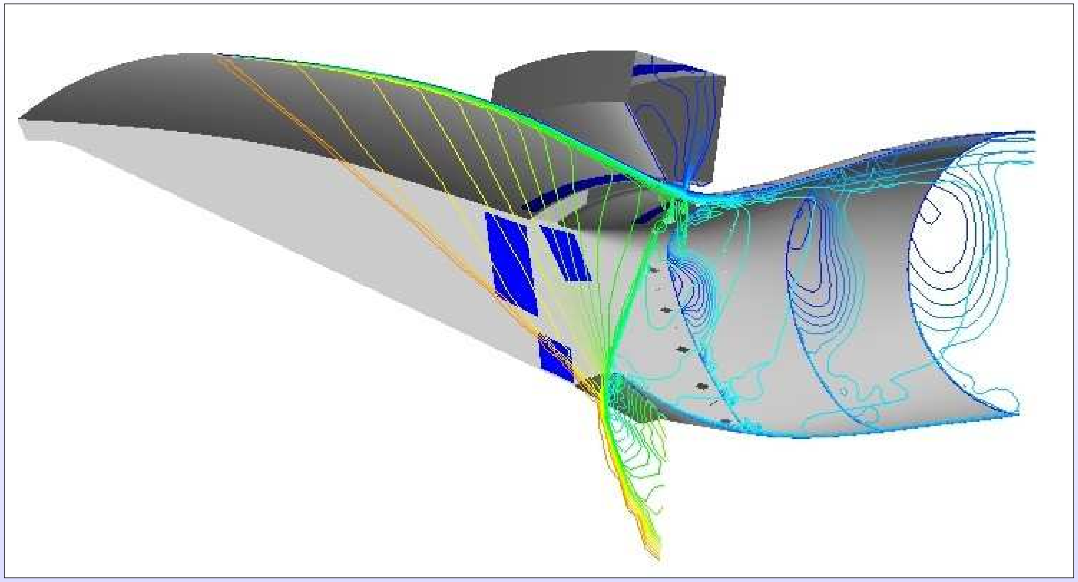
External-compression, supersonic inlet

CFD used the design

CFD supporting testing and validation

CFD Objectives

- Shock structure
- Steady-state performance
- Recovery –vs- mass flow (cane curve)
- Spillage
- Bleed locations and amount
- Best cowl lip and slot configuration (DOE methods)
- Off-design (Mach, α)



Analyses has demonstrated need for:

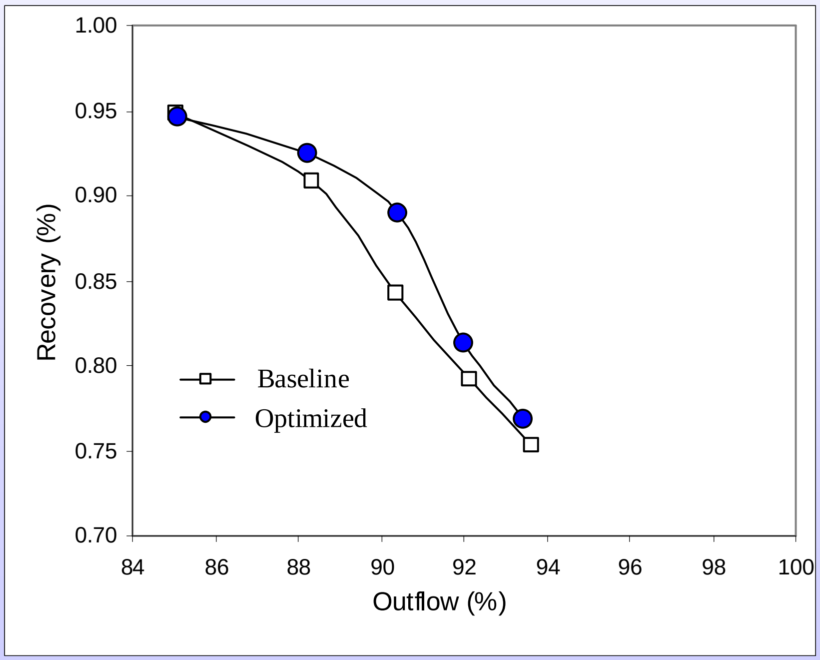
- Bleed models (adjustable mass flow)
- Vortex generator models
- Outflow boundary conditions

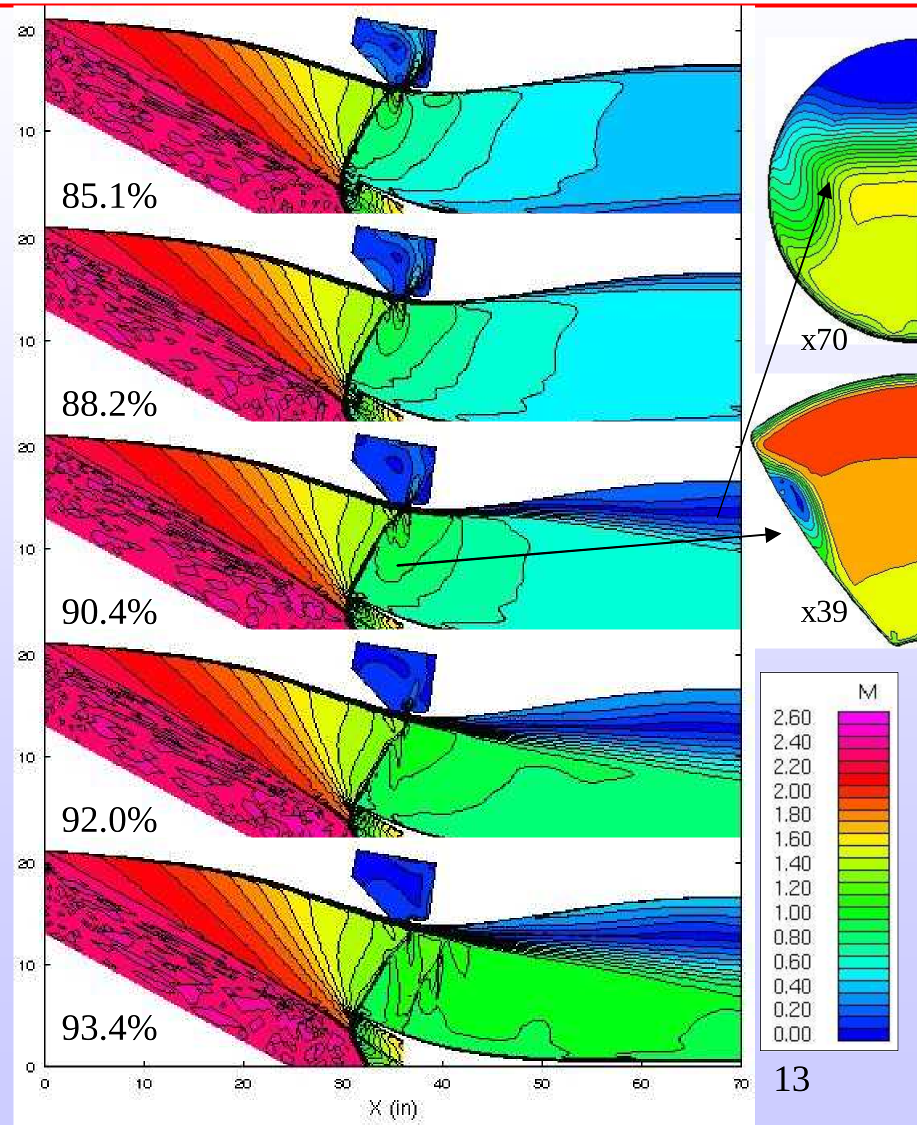
Researcher: John Slater (Inlet Branch)

“Optimized” Bleed Cane Curve

DOE study improved the performance of the inlet over the engine flow sweep

$P_{slot} = 3.5$ psi, $P_{corner} = 4.0$, $\Phi_{aft} = 30\%$





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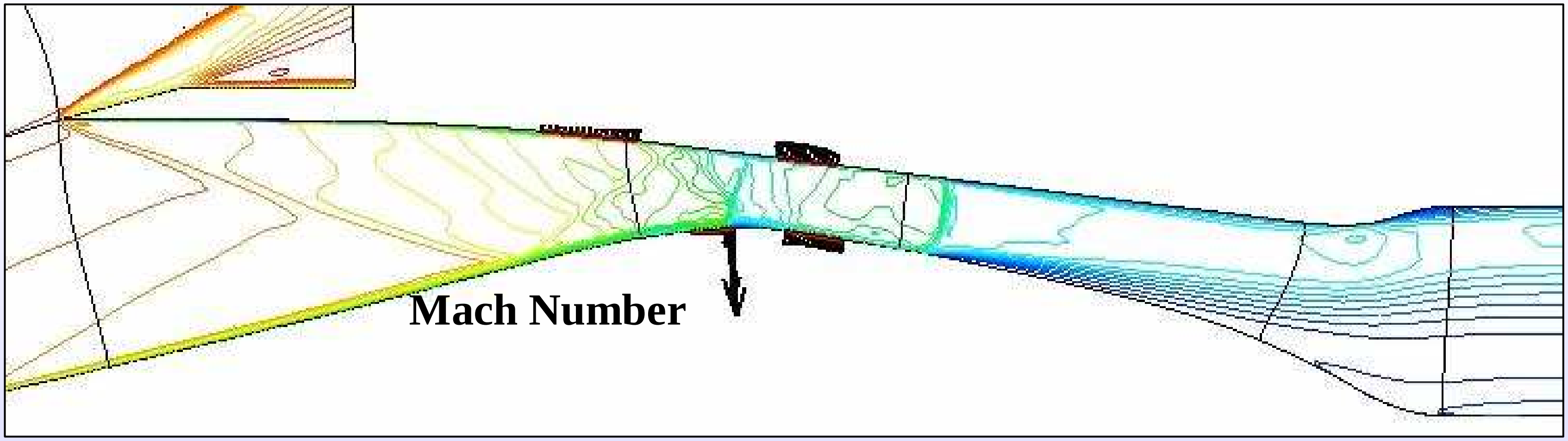
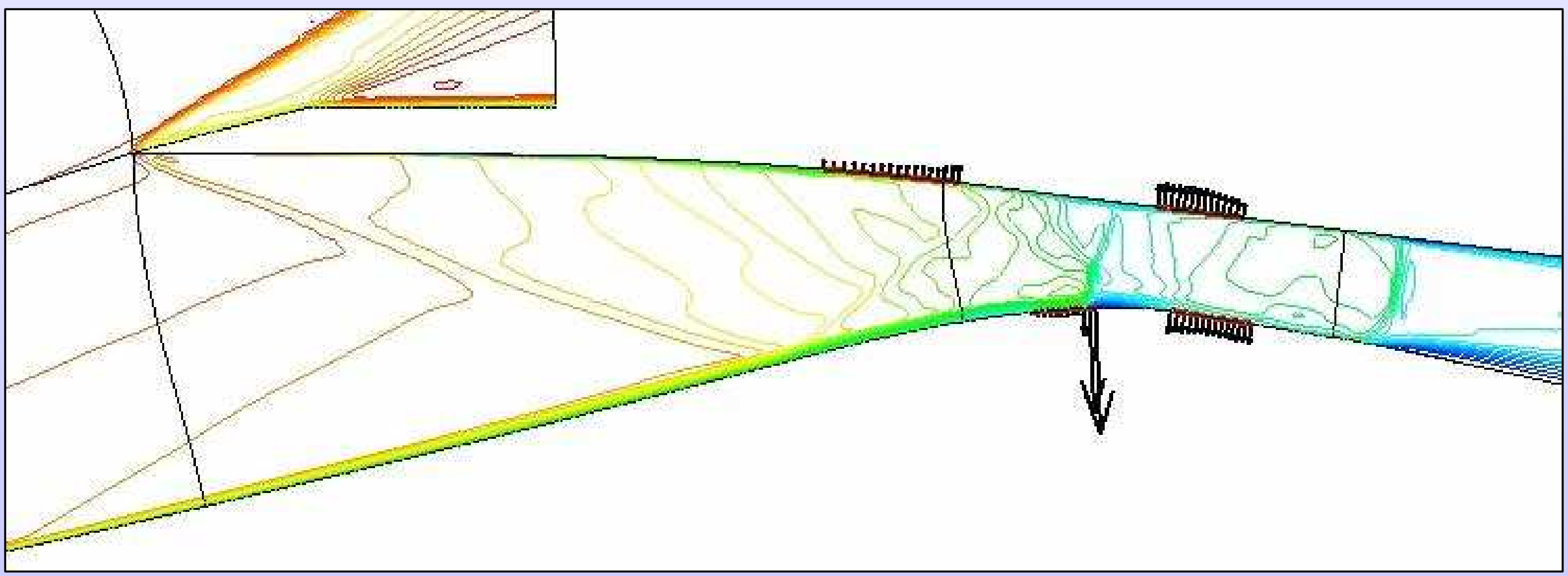
NASA Ames "4557" Inlet





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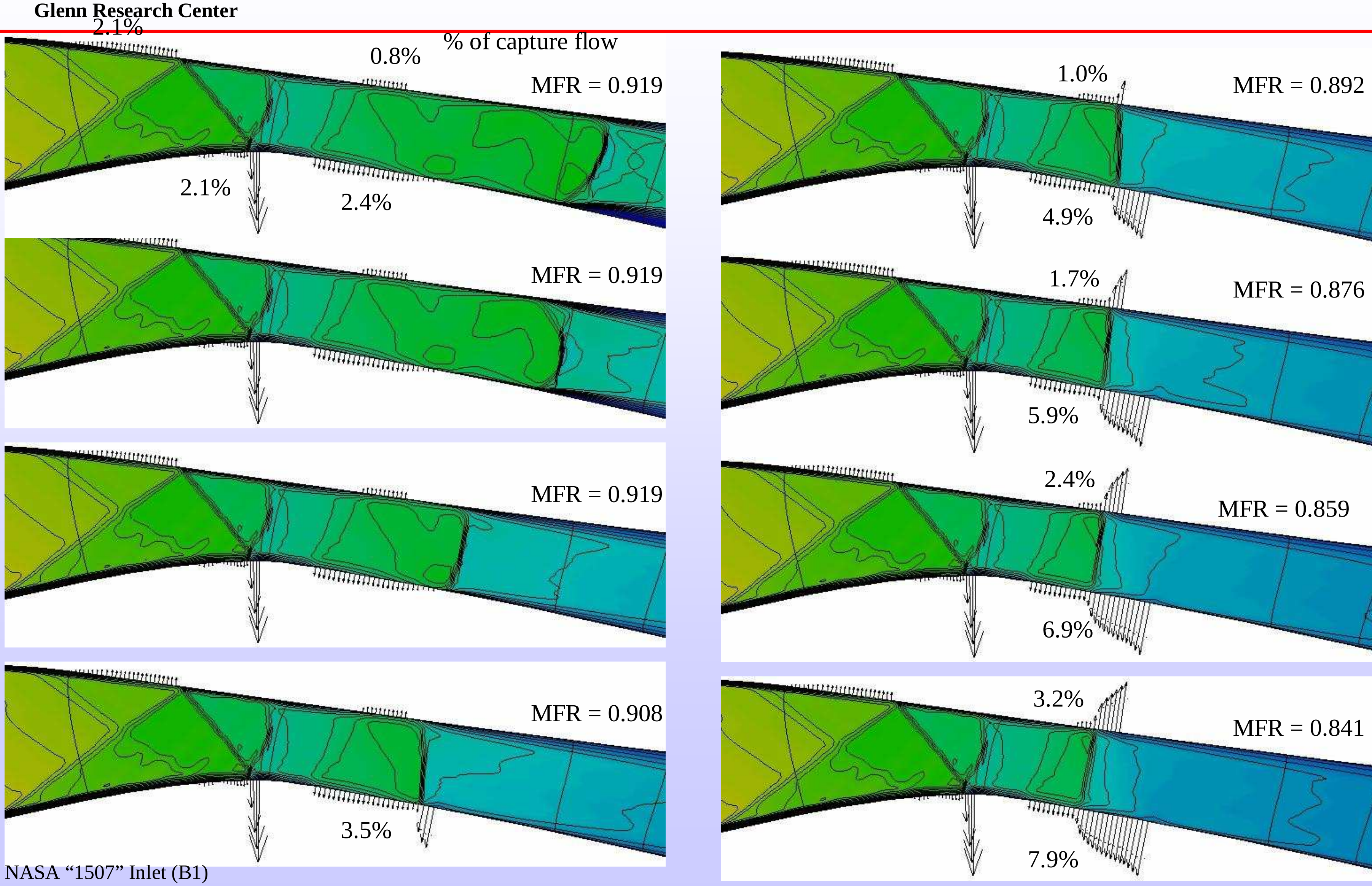
Interaction of Normal Shock with Bleed



NASA “1507” Inlet (B1)